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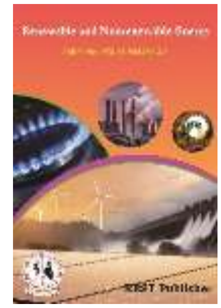

Engineering Design and Performance Analysis of a Portable Gas Leak Detector

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Abstract: *Now a days we find most of the fire accidents occurred are due to the leakage of gas cylinders which explode and cause lots of damage not only economically but also result in severe injuries and in some cases even human loss as well. Hence a source or device is needed for testing the leakage of gas in a cylinder within the industry before it is delivered to the consumer. One such type of device is the Portable Gas Leak Tester. The main objective of the project includes Modelling and analysis of a Portable Gas Leak Tester. In the present work, an attempt is made to evaluate the performance of the PGLT model through FEA. The PGLT model is the assembly of various sub parts like O-ring tester upper body, tester lower body, tester nozzle, holder, cantering cone, O-rings, indicator cover. Static analysis and Dynamic analysis is performed on two different models, one is the model assembly of parts made by the materials SS 316, PVC and the other is the model assembly of the parts made by the materials SS 316, PVC, Al6061 materials to evaluate the performance of each model under same load conditions such that some parts made by SS 316 replaced with Al 6061 which reduces the weight and cost of the model. Comparison is done for the two models based on the materials used for the parts and concludes with the better model. Modelling is done using Pro/Engineer (Creo Parametric 2.0) software and Analysis is done using ANSYS.*

Keywords: *Gas Leak detection, Portable Gas Leak Tester (PGLT), Stainless Steel 316, Aluminium 6061, PVC.*

1. INTRODUCTION

Portable gas leak tester: A Portable gas leak tester is a device used to test the leakage of gas from a gas cylinder inlet. The leakage may be due to various reasons like worn and tear of the cylinder inlet due to continuous usage etc. It is an assembly of various seven sub parts like upper tester body, lower tester body, centering cone, nozzle, indicator cover, holder, pressure indicator along with some o rings and . This type of devices is mostly used in gas filling units like LPG industry etc. Generally, the conventional method used for testing the presence of leakage is water bubble method. In this method the test is carried out by pouring droplets of water at the hose of the gas cylinder. If water bubbles come to appear at the hose then it is an indication of the presence of leak in the cylinder. But using a portable gas leak tester could be advantageous in that manner of reduction of the time spent on testing comparable to the conventional methods. The leak detection is carried out by using the parameter so called pressure. The pressure of the gas molecules that collide with the pressure indicator gives the actual pressure of the gas present in the cylinder. If the pressure level gradually decreases in the indicator that will be a sign of leak existing in the cylinder such that the cylinder is rejected at the time of inspection if it is not so then there is no leak present in the cylinder. This type of equipment is used to detect a gas leak and interface with in the LPG industry before the cylinder is certified to get dispatched to deliver into the market. A number of reviews on the subject of gas leak detection techniques were done in the past either as part of research papers/technical reports on a certain leak detection method and other gas related subjects This type of devices also can be used at home, commercial restaurants etc., wherever LPG cylinders are used. Because due to continuous usage of the same cylinder for filling, connecting to gas stoves through regulators etc., the inlet of the cylinder may get worn out or may some cracks occur at the inlet which may be a reason for the gas leak. Hence care must be taken in such cases otherwise it may lead to dangerous fire accidents which may hurt people severely. Usage of PGLT is for notification of leakage in home & environment applications. The usage of this type of device has become important because there are many such cases that we have been seeing for many days like fire accidents due to such leakage of gas. It is a highly sensitive device and the range of pressure that it can measure is 0 bar to 8 bar. It is a known fact that a gas plant is known in accordance with its final output. So we have LPG gas plant producing LPG gas, oxygen gas plant producing oxygen, nitrogen gas plant producing nitrogen, acetylene gas plant producing acetylene and so on. This implies that the gases available are the main raw materials used in gas plants, without which the existence of a gas plant has no meaning. Accordingly the manufacturers and suppliers are involved in the production of certain gases which are useful in various industrial and commercial, including residential applications. There are different types of gases on the basis of which a plant is installed and these gases are supplied to the market through cylinders. Hence there is a need of such leak tester such that to make sure that it is leak proof.

2. TYPES OF PGLT

The Portable Gas Leak Testers are classified into two types based on their contact with the hose of the cylinder. They are as follows:

- Contact type PGLT
- Non-Contact type PGLT

Though the principle in both type of testers is same but it differs in their tye of contact with the hose of the cylinder

- Contact type PGLT: In this type of tester the device comes with a direct contact with the pin in the hose of the cylinder. The nozzle present inside the device have a srew shaped ending with a hole throughout and gets engaged with the pin present at the hose of the cylinder. Then the gas flows through the nozzle towards the pressure indicator. The pressure level increases initially to a maximum value and then if any leak is present then gradually the level drops down. This type of PGLT is more accurate in deciding the gas leak since there is no way to the gas to escape.

- Non-Contact type PGLT: In this type of tester the device comes with an indirect contact with the hose of the cylinder. The device is just placed on the top of the hose with the help of centering cone and it houses onto the hose. The hole present in the O-Ring tester body helps for the gas flow into the device. If there is a leak present at the hose the then the gas flows through the hole towards the pressure indicator. Then the pressure level gradually increases indicating the a leak presence in the cylinder.

The Flow of Gas through Portable gas leak tester:

- Gas enters the Portable gas leak tester directly from the cylinder
- Gas is channelled into a chamber, where it passes to the tip of the pressure indicator.
- Gas is then channelled up out of the chamber and past the gauge pin
- Gas then exits through the whole present at the side of the nozzle.

The circumstances for a leak can be:

- Cracking of the hose due to regular wear and tear
- Disconnection of the hose by accident
- Weakening of the hose due to spillage of food / oil and consequential deterioration
- Regulator failure delivers unreduced cylinder pressure
- Hose is burnt off due to the ignition of small leaks
- If the cylinder is accidentally knocked over on its side
- Damages to gas tube caused by rodents.

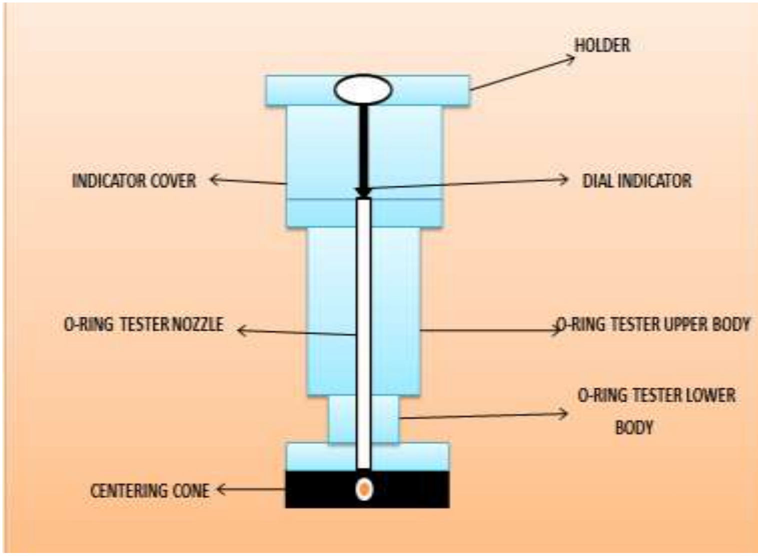


FIGURE 1 Model of PGLT

3. LITERATURE REVIEW

A.Mahalingam, R.T.Naayagi, N.E.Mastorakis [1] Gas leakage is a major concern with residential, commercial premises and gas powered transportation vehicles. One of the preventive measures to avoid the danger associated with gas leakage is to install a gas leakage detector at vulnerable locations. The objective of this work is to present the design of a cost effective automatic alarm system which can detect liquefied petroleum gas leakage in various premises. Test results are demonstrated for an USB powered gas leakage detection system and it gives early warning signals under less severe conditions and activates a high pitched alarm in case of emergency situations to the users.

T.Soundarya, J.V.Anchitaalagammai, G.Deepa Priya, S.S.Karthick Kumar [2] Home Fires have taken a growing toll in lives and property in recent years. LPG is highly inflammable and can burn even at some distance from the source of leakage. Most fire accidents are caused because of a poor-quality rubber tube or when the regulator is not turned off. The supply of gas from the regulator to the burner is on even after the regulator is switched off. By accident, if the knob is turned on results in the gas leaks. This paper deals with the detection, monitoring and control system of LPG leakage. Using relay DC motor the stove knob is automatically controlled. Along with safety measures the system has additional advantage of automatic rebooking of cylinder when the level of gas goes below the normal weight of cylinder. Pal-Stefan Murvay, Ioan Silea [7] Gas leaks can cause major accidents resulting in both human injuries and financial losses. To avoid such situations, a considerable amount of effort has been devoted to the development of reliable techniques for detecting gas leakage. As knowing about the existence of a leak is not always enough to launch a corrective action, some of the leak detection techniques were designed to allow the possibility of locating the leak. The main purpose of this paper is to identify the state of the art in leak detection and localization methods. Additionally we evaluate the capabilities of these techniques in order to identify the advantages and disadvantages of using each leak detection solution.

4. MODELING & ASSEMBLY OF PARTS OF PGLT

In this section the modeling of Portable gas leak tester parts design is done in Pro/E modeling software.

O-Ring Tester lower body:

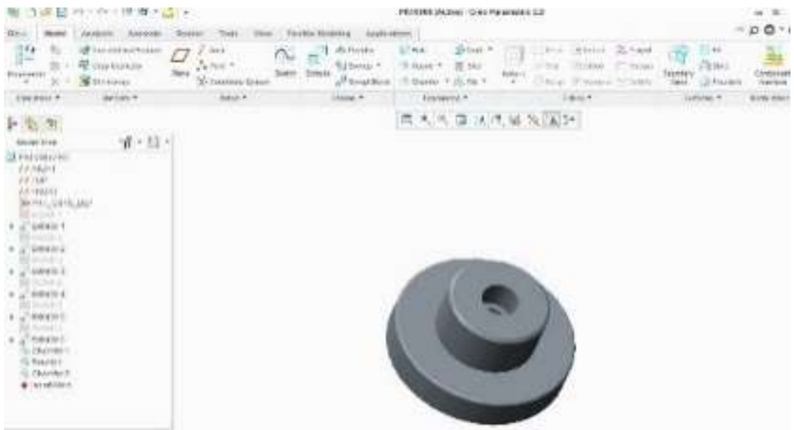


FIGURE-2. O-Ring Tester lower body

O-Ring tester upper body:

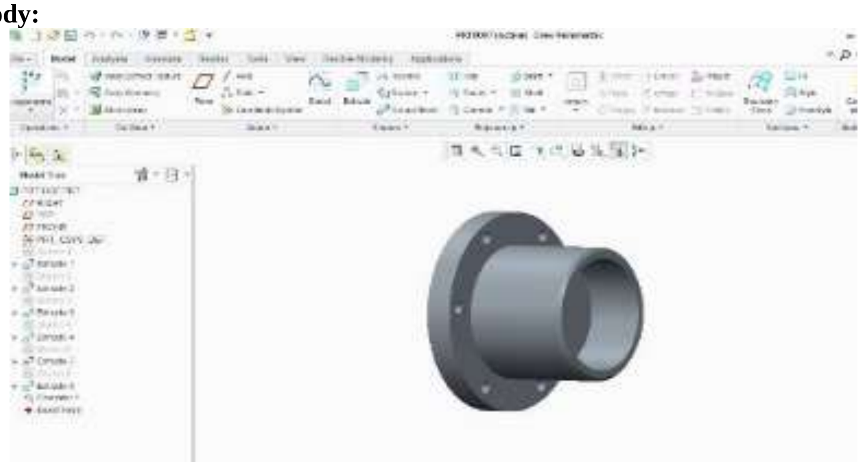


FIGURE 3 .O-Ring tester upper body

Indicator Cover:

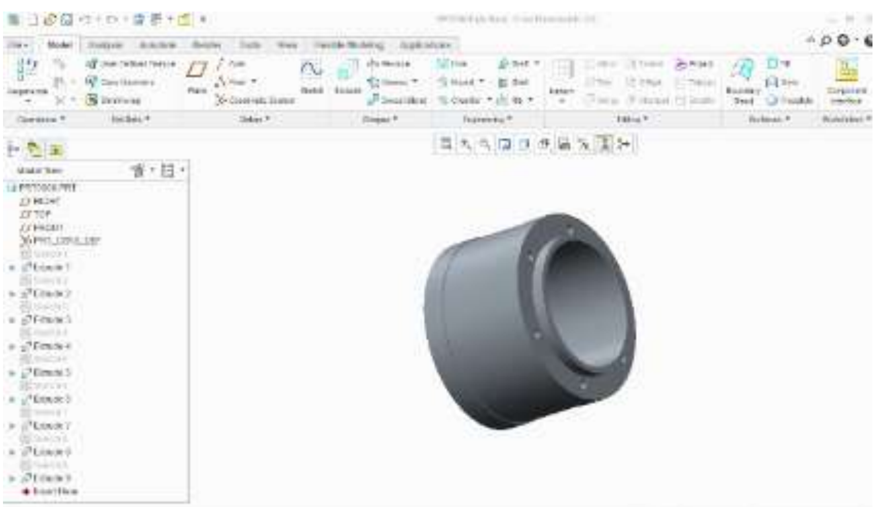


FIGURE 4. Indicator Cover

Holder:

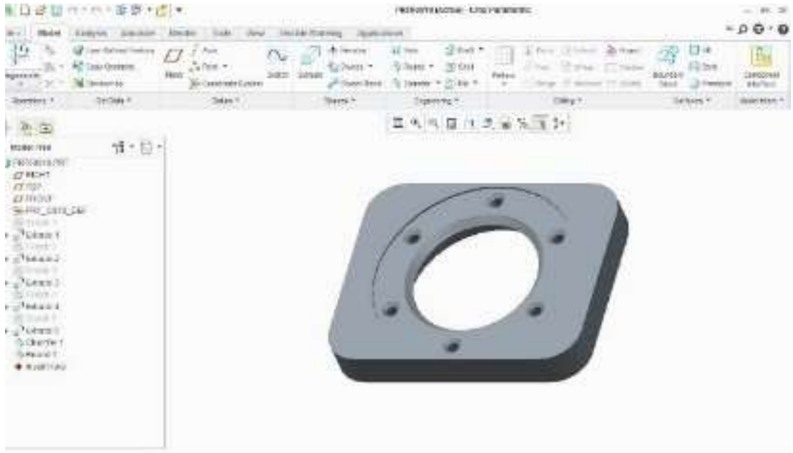


FIGURE 5. Holder

Nozzle:

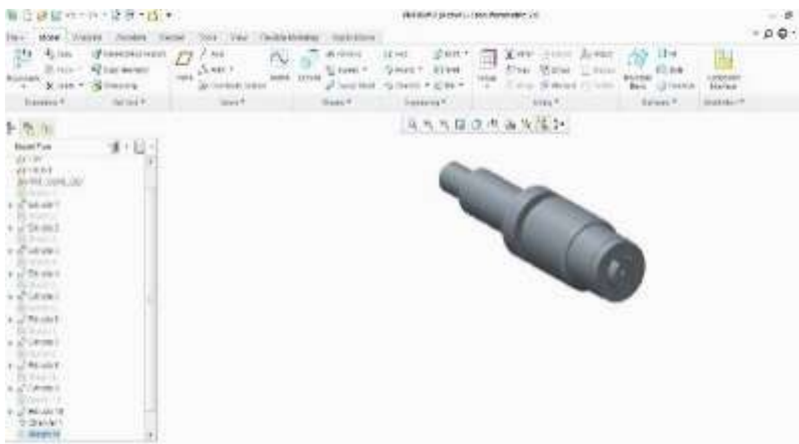


FIGURE 6. Nozzle

Centering Cone:

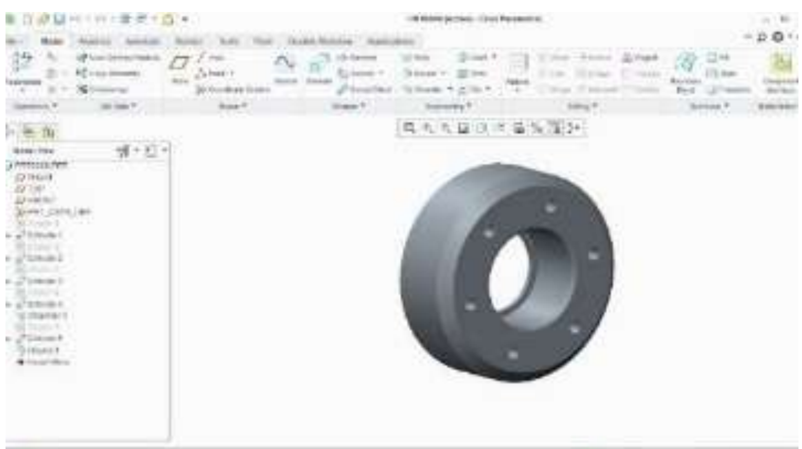


FIGURE 7. Centering Cone

Screw Fastener:

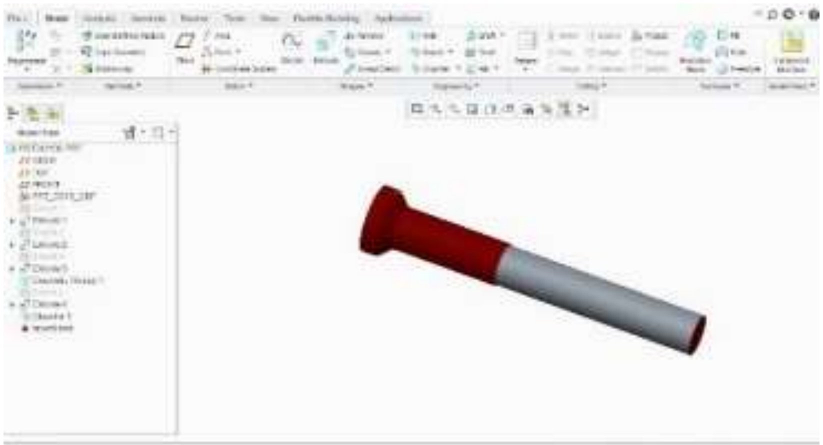


FIGURE 8. Screw Fastener

Assembly of PGLT:

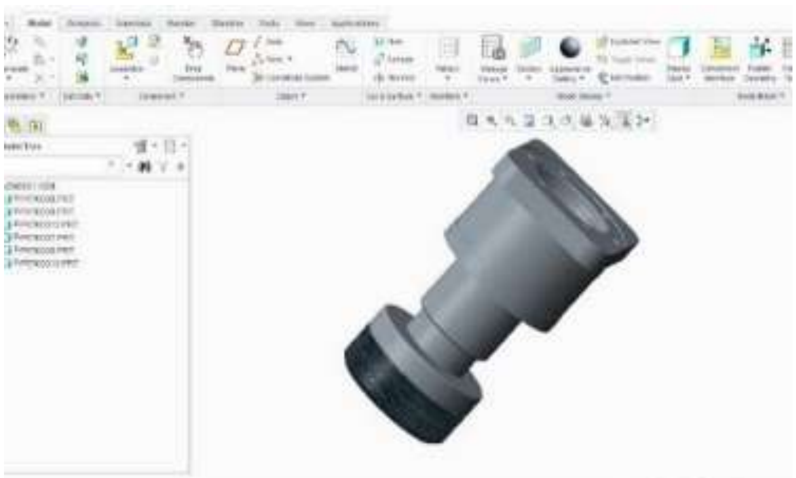


FIGURE 9. Assembly of PGLT

TABLE 1 .Properties of Composite Materials

	SS 316	Al 6061	PVC
ELASTIC MODULUS	193 GPa	68.9 GPa	1.80-2.41 GPa
POISSON RATIO	0.27	0.33	0.4
DENSITY	8 g/cc	2.70 g/cc	0.60-1.36 g/cc
YIELD STRENGTH	290 MPa	55.2 Mpa	31-40.8 MPa

5. ANALYSIS

A. STATIC ANALYSIS:

A structural model which created can be used to predict the behaviour of their modal structure, under the action of external forces. The response is usually measured in terms of deflection and stress. The response is static if the loads are steady. This analysis is called static analysis. A static analysis can be either linear or non-linear.

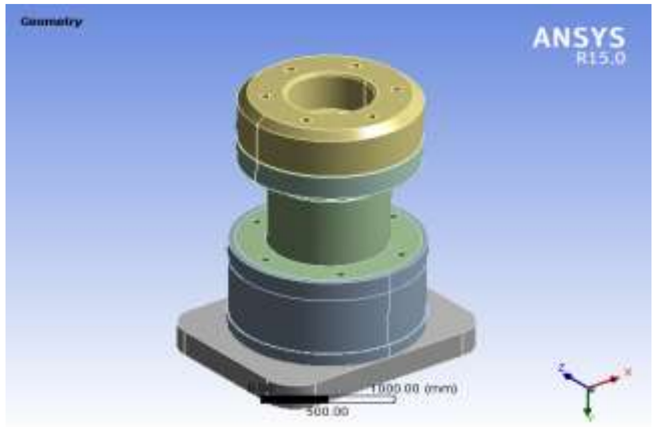


FIGURE 10. Importing model of PGLT

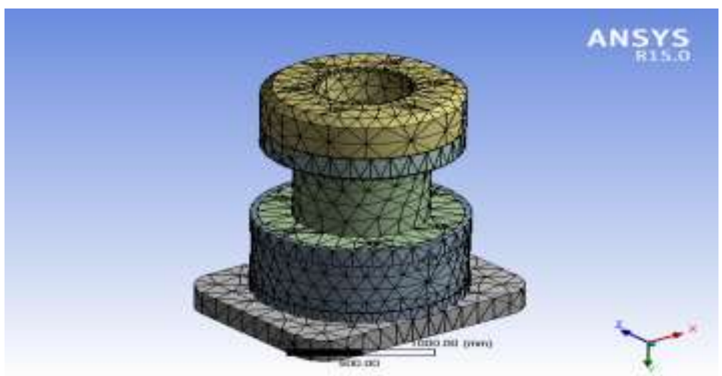


FIGURE 11. Meshing model of PGLT

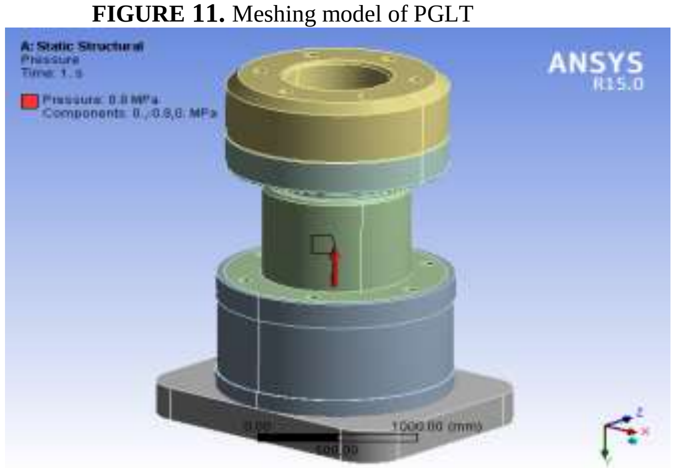


FIGURE 12. Load applied on the model of PGLT

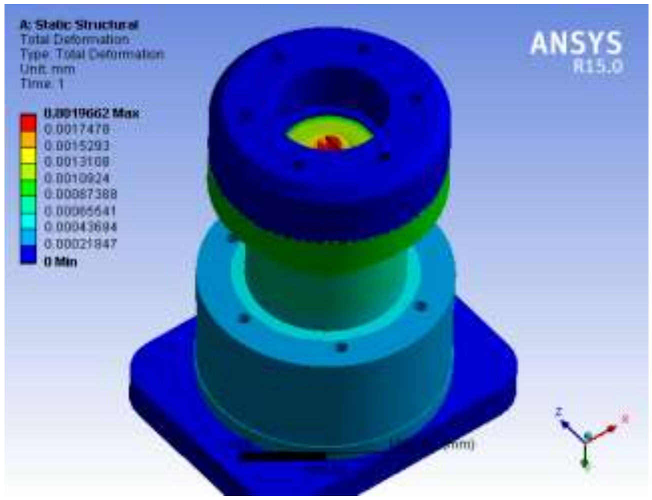


FIGURE 13. Total Deformation in optimised PGLT model

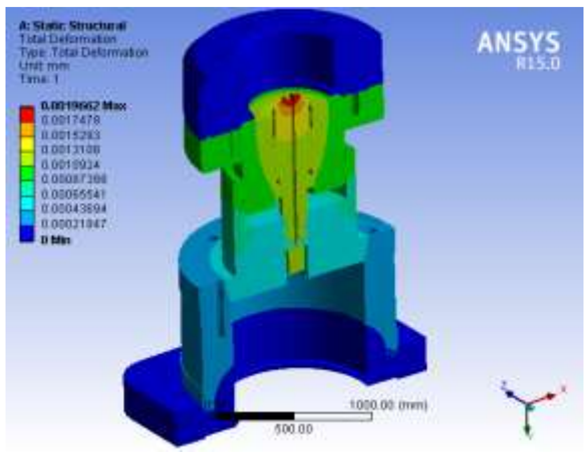


FIGURE 14. Sectional view of Total Deformation in optimised PGLT model

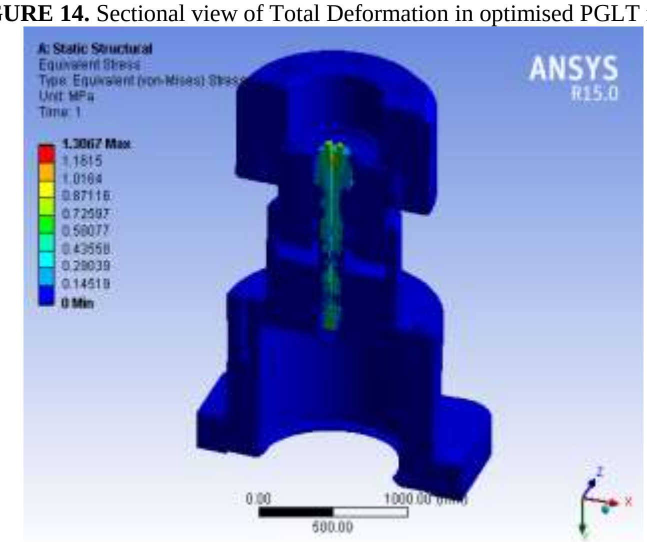
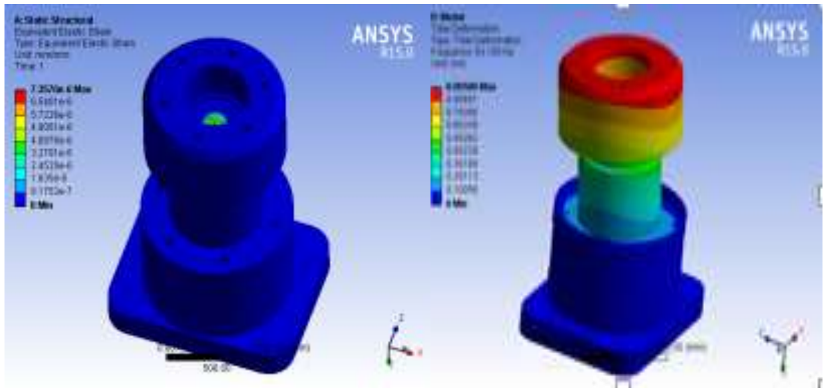


FIGURE 15. Von-misses stress in the optimized PGLT model



Strain in the optimized PGLT model

TABLE 2. Static analysis results

	Initial PGLT model	Optimized PGLT model
Von-misses Stress (Mpa)	1.3071	1.3067
Strain	7.3596e-6	7.3576e-6
Strain	0.0011852	0.0019662

B. DYNAMIC FINITE ELEMENT ANALYSIS

Dynamic finite element analysis of the PGLT mainly refers to the vibration modal analysis using the finite Element theory. Modal analysis is used to identify natural frequencies, especially low-order frequencies and vibration modes of the model. From the modal we can learn in which frequency range the model that will be more sensitive to vibrate. In this paper, the finite model of the PGLT has been established in ANSYS by importing the PGLT surface model created previously. Modal analysis is carried out to check whether the mechanical properties of the model meet certain safety requirements.

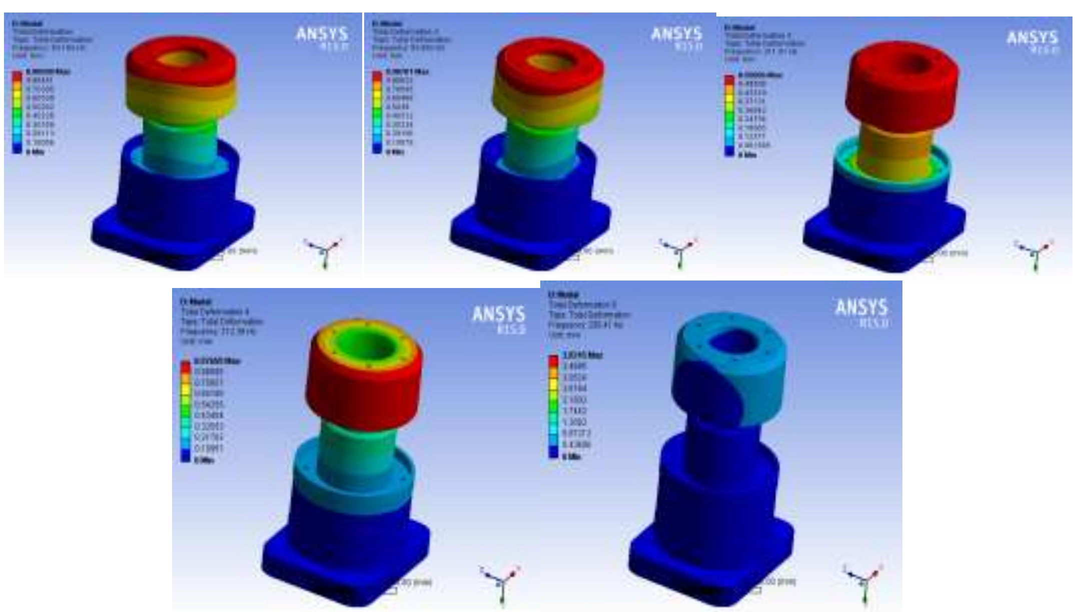


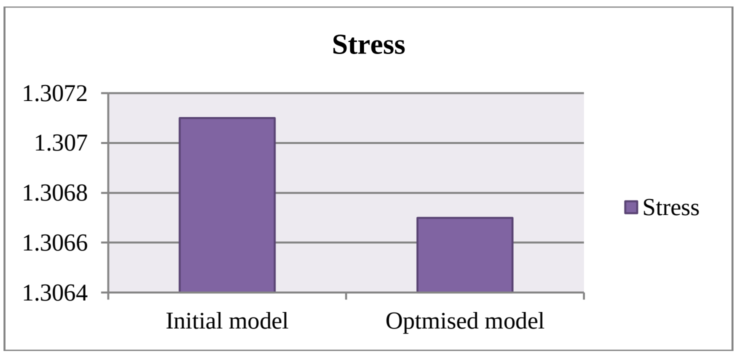
TABLE 3 .Modal Analysis Results

	Initial PGLT model	Optimised PGLT model
mode 1 in Hz	85.557	83.165
mode 2 in Hz	86.095	83.693
mode 3 in Hz	212.69	211.01
mode 4 in Hz	219.75	212.39
mode 5 in Hz	281.74	258.41

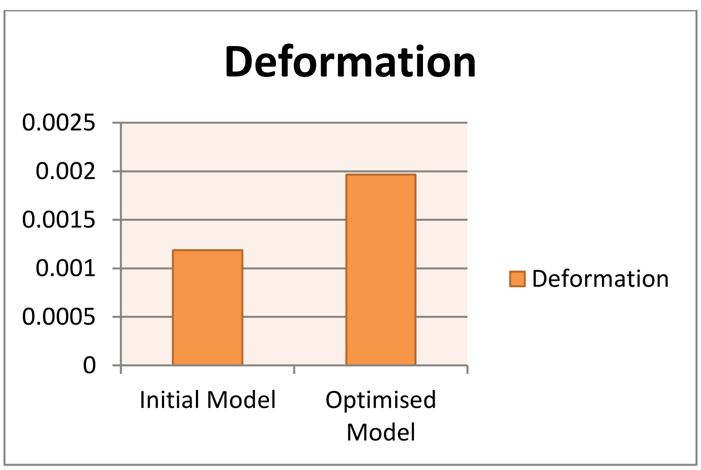
6. GRAPHS & DISCUSSIONS

According to results of structural analysis graphs are plotted for the initial PGLT model and optimized PGLT model. Graphs are plotted for the Von-mises stress, strain, Deformation, cost, weight. Structural analysis has been carried out on both initial and optimized models of PGLT. From the structural analysis it is found that at load the deformation in the PGLT with SS316 and PVC combination is 0.0011852 mm and corresponding deformation with the Al 6061, SS316 and PVC combination is 0.0019662 mm. However, the difference is negligible when compared with the weight of the device. The von-misses stress in the existing model is 1.3071 MPa and corresponding von-misses stress in the optimised model is 1.3067 Mpa ANSYS was adopted to establish the PGLT model so as to describe actual shape and layer structure of the model precisely. The dynamic performance of the both models was checked by modal analysis, providing a reference for structure design and other analyses. Hence the optimized model better compared to the existing PGLT model based on the total deformation, von-mises stress, and weight and cost values obtained.

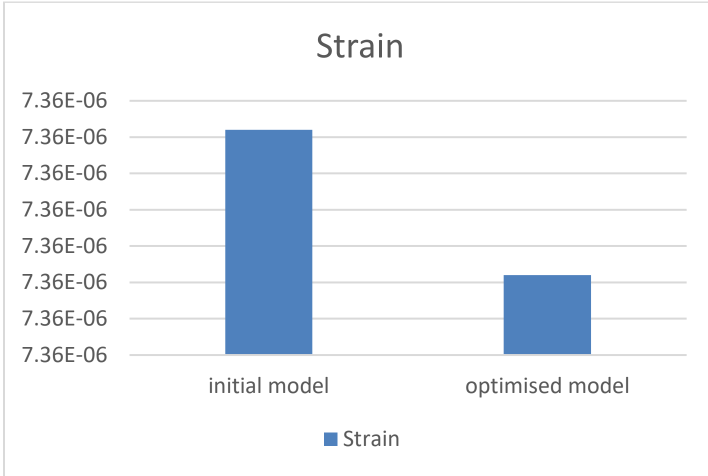
A. Von -Mises Stress in Materials



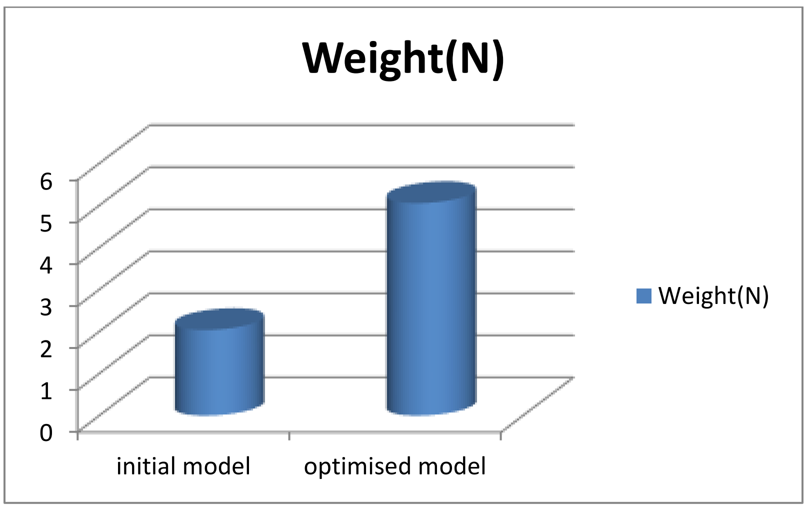
B. Deformation in Materials



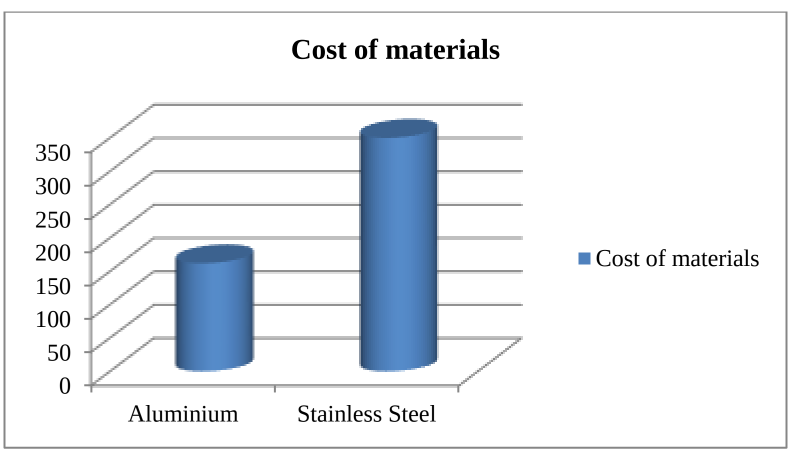
C. Strain in both models:



D. Weights of both models



E.Cost of Materials



7. CONCLUSION

This paper applied to optimization design and analysis of a Portable Gas Leak Tester. The way of combining Pro/E and ANSYS was adopted to establish the PGLT model precisely. Structural analysis and Dynamic analysis has been carried out on the assembly of the parts made by materials SS316, PVC and the other combination with Al6061, SS316andPVC. The dynamic performance of the models are checked by modal analysis. Hence the optimized model combination gives better results compared to the proposed model based on the total deformation, von-mises stress, strain, and weight and cost values obtained.

Scope of Future Work: The present work can be extended by choosing only other non-corrosive material for the parts covering the nozzle and the pressure indicator having higher stiffness to reduce defection in model.

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